Roadside Safety Review

by Rich Peter

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Review Continues to Provide Roadside Safety Updates

The *Roadside Safety Review,* published by the Division of Engineering Services' Roadside Safety Technology Branch (RSTB), provides updates to key Departmental staff on the most recent developments in roadside safety. Such developments discussed in this issue include:

- Changes in the membership of the Highway Safety Features New Products Committee.
- New products and designs that have been approved for use on the state highway system or that have been recommended for approval.
- Recently completed, ongoing and planned roadside safety studies and research.

If readers have questions regarding any item that appears in this issue of the *Review*, please contact Rich Peter at (916) 227-7257, 8-498-7257 or rich_peter@dot.ca.gov.

HSFNPC Membership Changes

The Highway Safety Features New Products Committee (HSFNPC) is responsible for evaluating new roadside safety hardware and recommending approval for use on the state highway system. This applies to proprietary hardware as well as hardware designs developed and tested by the Department. The HSFNPC has representatives from most Headquarters Divisions as well as a District representative. This committee plays a crucial role in representing a broad spectrum of technical and program interests. Please contact your representative if there are any concerns you want the committee to address.

There have been some recent changes on the committee. The members currently include:

Ellis Hirst – Traffic Operations (Chair) (916) 654-2465

Rich Peter – Engineering Services, METS (Vice-Chair) (916) 227-7257

John Jewell – Engineering Services, METS (Secretary) (916) 227-7125

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HSFNPC

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Robert Peterson – D3 (Representative for Districts) (530) 822-7560

Nahed Abdin – Engr. Services, Structures Design (916) 227-8805

Robert Meline – New Technology and Research (916) 227-7031

P.J. Caldwell – Maintenance (916) 684-1822

Joy Pinne – Construction (916) 654-5627

David Cordova – Design and Local Programs (916) 653-0485

Keith Robinson – HQ Landscape Architecture (916) 654-6200

Tim Craggs – Design and Local Programs (916) 653-4882

Although not a member of the committee, Matthew Schmitz of FHWA often attends HSFNPC meetings to provide his agency's perspective on roadside safety issues. Mr. Schmitz can be reached at (916) 498-5850.

Department Approves More New Products

Since the July 2001 *Review* was published, the HSFNPC has evaluated several new roadside safety products and designs and recommended that they be approved. This evaluation is based primarily on the new products' conformance with the criteria embodied in National Cooperative Highway Research Program (NCHRP) Report 350. These new roadside safety products include:

Merritt Parkway Guiderail and Steel-Backed Timber Guardrail

These non-proprietary rails are aesthetic alternatives to metal beam guardrail in scenic areas where a more rustic appearance is desired. Both of these devices feature heavy timber rails with a steel strap screwed to the back side to provide additional tensile strength. The Merritt Parkway Guiderail uses steel posts while the steel-backed timber guardrail uses timber posts. On the downside, there are no crashworthy end treatments or approved transition sections for either of these rails and they are quite expensive to install.

Steel-Backed Timber Guardrail

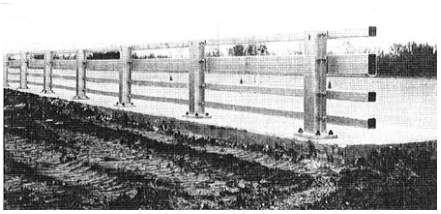
TAU-II™ Crash Cushion

This crash cushion, manufactured by Barrier Systems, Inc., is similar in concept to Energy Absorption Systems' QuadGuard. The TAU-II™ features a number of energy absorbing plastic modules supported between steel diaphragms with slotted thrie beam panels on the sides. When struck on the upstream end, the entire system telescopes and slides back, crushing the plastic modules. The system is available in both in test level 2 (TL-2) and test level 3 (TL-3) configurations. TL-2 systems are designed for low-speed (70 km/h) applications, while TL-3 systems are rated for high-speed (100 km/h) conditions.

TAU-II™ Crash Cushion

NETC 4-Bar Bridge Rail

The New England Transportation Consortium (NETC) 4-Bar Bridge Rail is a steel see-through design that offers an aesthetic alternative to other bridge rail designs currently used by the Department. The non-proprietary NETC rail is mounted on a sidewalk and has a total height of 1067 mm to ensure pedestrian safety.



NETC 4-Bar Bridge Rail

Type F Callbox

Call boxes are located adjacent to state highways throughout much of California. These are installed and maintained by local Service Authority for Freeways and Expressways (SAFE) offices with encroachment permits issued by the Department. The SAFEs have been working with the Department to ensure that these call box installations are crashworthy and a new standard design, the Type F, was recently crash tested and evaluated. The Type F callbox system is mounted behind an asphalt concrete dike but is still accessible to handicapped individuals.

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New Products

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Other call box installation configurations will be crash tested and evaluated in the near future through a contract between the SAFEs and the Texas Transportation Institute.

Three-Cable Median Barrier

Cable median barrier that was installed on California state highways decades ago mostly been replaced by better-performing and lower maintenance concrete and metal beam median barrier. However, modern cable barrier designs perform significantly better than the cable barrier of the 1950s and 60s, and they have some advantages over concrete and metal beam median barrier. They are very inexpensive and can be constructed quickly. They are also comparatively "forgiving" barriers that can bring impacting vehicles to a relatively gradual stop even in large-angle hits.

A three-cable design used by Washington, New York and other states has performed very well in crash tests. The Department has approved this barrier with the intention that it may only be used under certain circumstances. An example would be where construction of a concrete or metal beam barrier has been programmed, but an interim barrier is needed that can be constructed quickly. There are some disadvantages to cable barrier, including high maintenance requirements and large deflections during impact. Consequently, the following is needed before this barrier can be used:

1. Concurrence of the District Traffic Liaison engineer,

2. Approval of the HSFNPC Chair (Ellis Hirst at 8-453-2465) and

3. An approved Construction Evaluated Work Plan (Pat Aust at 8-453-4337).

Amity Guardrail Posts

Amity Plastics, Ltd., a Canadian firm, has developed a guardrail post made of steel-reinforced, recycled plastic that performs much like conventional steel and wood posts in crash tests. The Amity post was tested with conventional wood blockouts, although approved recycled plastic blockouts should also be a satisfactory alternative. Amity Plastics has indicated that they plan to fabricate posts in the U.S. to make their product more cost-competitive

Amity Plastic Guardrail Post

SafeGuard™ Gate System

The SafeGuard™ Gate System, manufactured by Barrier Systems, Inc., is an alternative to Energy Absorption Systems' Barriergate™ that was approved by the Department several years ago. Both of these systems consist of steel gates that open to create a gap in a median barrier, permitting vehicles to cross the median in an emergency. Although the BarrierGate can be opened manually with some difficulty, it normally uses an electric motor to slide back along a track to open. The SafeGuard™ Gate System, on the other hand, works on a different principle. This device uses a compressed air jacking system with wheels (compressed air must be provided from an external source) to raise the gate off the ground. The gate can then be disconnected from the permanent barrier at each end and pushed out of the way. The manufacturer claims that two persons can push this gate with the jacks in the down position.

This gate is available in lengths of 8, 12 and 16 meters. It is currently designed only to connect to Type 50 median barrier, but Barrier Systems indicates that they can make adaptor sections for Type 60 barrier.

Safeguard™ Gate System

White Mountain Guardrail Posts & Blockouts

Wood guardrail posts and blockouts are normally solid pieces of Douglas fir or Southern yellow pine. Imperial Laminators has developed a new design of posts and blockouts that are constructed of laminated Ponderosa pine. Each post and blockout has cross-sectional dimensions identical to the standard, solid wood versions (150 mm

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New Products

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x 200 mm) and is fabricated by gluing five pine laminations together. Crash testing indicates that these posts and blockouts perform in a manner very similar to the standard, solid wood versions. The advantage of the laminated posts relative to the solid wood posts is that the laminated posts can be manufactured from much smaller trees, resulting in reduced manufacturing costs.

Crashworthy Mailboxes

The Department frequently relocates and replaces mailboxes during highway widening and reconstruction projects. Crash testing has demonstrated that some commonly used mailboxes and mailbox support systems perform in an undesirable manner when impacted by moving vehicles. For example, the popular steel mailbox mounted on a 100-mm x 100-mm wood post usually separates from the post upon impact and may penetrate the windshield of the impacting vehicle.

The HSFNPC has recommended that the Department use only crashworthy mailboxes and/or support systems for construction-related mailbox installations or relocations. The following types of mailboxes and support systems are considered to be crashworthy:

1. Mailboxes/support systems that have been successfully crash tested and accepted by FHWA for use on the National Highway System. One example is the V-Loc Mailbox Support System.

2. All AASHTO-approved mailbox and support system designs. This includes mailboxes that are secured to the support post with a special bracket that prevents the box from separating from the post.

3. Molded plastic mailboxes and support systems using 100-mm x 100-mm wood posts. Such systems have been successfully crash tested. The molded plastic is flexible enough to preclude windshield penetration. The Step 2 Company and Rubbermaid are two manufacturers that produce such designs.

REACT 350™ (60")

The Department approved the standard REACT 350™ several years ago and the device has proven to be a durable, low-maintenance crash cushion. The standard REACT consists of a single row of nine, high-density polyethylene cylinders with an outer diameter of 914 mm (36 in). The REACT 350™ (60") is a wider version of the original REACT, and is designed to protect obstacles up to 1524-mm (60 in) in width. This model comprises two parallel rows of 13 polyethylene cylinders with diameters of 610 mm (24 in) plus a single cylinder on the nose, for a total of 27 cylinders.

REACT 350™ (60")

To date, Headquarters Division of Traffic Operations has acted on the HSFNPC recommendations and approved the Merritt Parkway Guiderail and steel backed timber guardrail, the TAU II crash cushion, the NETC 4-bar bridge rail and the three-cable median barrier. Approval of the other devices is pending.

A significant change has been made to the approval process. In the past, most new products initially received "experimental" approval. Use of such products required Headquarters' concurrence and installations were supposed to be monitored for an extended period of time to determine how the products performed. Only after an "experimental" product displayed acceptable performance for one to four years would it receive an "operational" designation. This distinction between types of approvals has been dropped, and all new product approvals are essentially "operational." However, conditions may still be placed on the use of the new product in some cases. As an example, please refer to the discussion of the three-cable barrier on the preceding page.

District 3 Tests Pine Post Longevity

For many years the Department used Douglas fir exclusively for wood guardrail posts. During the last decade, the Standard Specifications were modified to allow the use of Southern yellow pine for such posts as well. Southern yellow pine and Douglas fir have similar strength characteristics and the pine is used widely in other parts of the U.S., particularly in the east and south, where it is much less expensive than Douglas fir. The price of Southern yellow pine has also become increasingly competitive in the west in recent years and pine is now being used on many construction projects on California state highways.

Concerns have been raised that the pine does not appear to weather well in California's dry climate and new posts quickly crack and split, potentially requiring early replacement. In order to determine how Southern yellow pine performs relative to Douglas fir under identical conditions, District 3 recently completed a guardrail project in which a portion of the posts were made from pine and the remainder from fir. The posts have been marked for identification and will be monitored

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Pine Posts

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regularly by District personnel. The results of this study will be reported in a future issue of the *Review*.

Textured Barrier Testing Completed

The Roadside Safety Technology Branch recently completed testing on a wide range of different aesthetic barrier textures. An advisory committee comprised largely of representatives from District and Headquarters Landscape Architecture and Headquarters Structures Architecture selected the textures to be tested.

RSTB staff used commercial formliners, plywood and other materials to cast textured concrete panels against the face of a Type 60G barrier located at the Caltrans Dynamic Test Facility in West Sacramento. These panels were securely connected to the barrier and subjected to vehicle crash tests using NCHRP Report 350 TL-3 criteria.

The RSTB tested a total of nine textures:

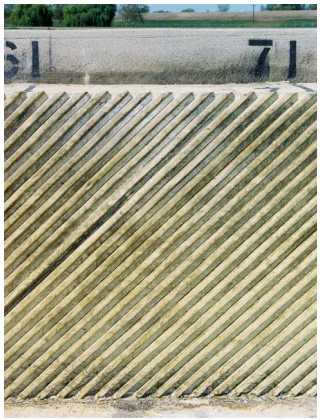
1. Large cobble
2. Diagonal rib
3. "Mission Arch"
4. Large cobble horizontal reveal (above 610 mm)
5. "Dry Stack"
6. Shallow relief cobble
7. "Fractured Granite"
8. "Light Sandblast"
9. "Heavy Sandblast"

Textures 8 and 9 above were not tested separately, but incorporated into some of the test panels featuring the first seven textures.

Large Cobble

The test vehicles snagged on the large cobble and shallow relief cobble, resulting in substantial occupant compartment deformation. The diagonal rib pattern (ribs angled 45 degrees to the roadway) caused the impacting vehicle to climb up the face of the barrier and roll over. These three textures were judged to be unacceptable. The rib pattern was also considered unacceptable regardless of angle because it was damaged so extensively by the impact of a subcompact sedan.

Shallow Relief Cobble



Diagonal Rib

The remaining textures all met the applicable NCHRP Report 350 criteria and were determined to be acceptable.

Based on these tests, the RSTB developed a set of guidelines for designers that describe acceptable concrete barrier texture characteristics. These guidelines provide designers with a nearly unlimited array of potential barrier texturing options. The HSFNPC has recommended approval of these guidelines and Department management is now reviewing them. The California Division of FHWA has issued an interim acceptance of the guidelines. Within approximately two months the guidelines will be submitted to FHWA's Washington office along with a final report for formal acceptance.

Mission Arch

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Textured Barrier

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This project has been the largest and most thorough evaluation of the crashworthiness of aesthetic barrier treatments ever conducted in the U.S. The research results are already being shared with other states and it is likely

that the guidelines will have widespread application.

Large Cobble Horizontal Reveal

There are some caveats that should be noted regarding the use of aesthetic treatments on concrete barriers. First, these treatments were tested on single-slope, Type 60 barrier. While these treatments may also be appropriate for other types of barriers, such as vertical face designs, treatments should NOT be used on multi-slope barriers such as the Type 50. These barriers are designed to promote vehicle climb as a means of absorbing energy, and impacting vehicles often climb to the top of such barriers. The addition of texture to the face of such a barrier could cause impacting vehicles to vault over it.

A second concern is construction cost. Most concrete barrier on California state highways is constructed using slip form technology, which is relatively inexpensive. The average installed cost of Type 60 barrier is currently about $92/m. Textured barrier, however, could easily cost twice that figure.

Dry Stack

Construction cost for textured barrier would generally include the purchase of formliners, hand placement of reinforcing steel, building the forms, and form removal and disposal, none of which are required for slip formed barriers. Machinery that rolls texturing onto slip formed concrete barriers has been developed and may reduce cost, but this technology is not yet well established and for the present the choice of textures is limited.

Fractured Granite

A final issue is maintenance. Many textured concrete barrier surfaces will be damaged more easily than smooth concrete surfaces would be. This damage will normally be cosmetic only (e.g., minor spalling), but because a high priority on aesthetics was the reason for texturing the barrier to begin with, there will be pressure to repair this damage. Such repairs may be difficult and costly and may expose maintenance workers to hazards from moving traffic. Maintenance issues must be addressed before textured barrier construction. If local agencies are involved, agreements should be negotiated regarding responsibility for maintenance and associated costs.

Type 60K Terminus Testing Complete

The July 2001 issue of the Review discussed the implementation of the new Type 60K portable concrete barrier that was designed for long-term applications. The Type 60K was specifically designed to fill openings in Type 60 median barriers during normal operations. When lane or freeway closures occur, the Department has the option of removing the Type 60K barrier from the openings and detouring traffic across the median.

With this application in mind, the Type 60K barrier was originally tested as if it were connected at both ends to permanent barrier. However, District 2 now has an additional need to use the Type 60K in a configuration where the downstream end of a line of barrier segments is free-standing (this end would be exposed to one-way traffic only). The stability and deflection characteristics of Type 60K barrier under such conditions were unknown, so this configuration was crash tested.

In the crash test, a 2000-kg pickup truck impacted near the downstream end of a line of Type 60K barrier elements. The last element deflected laterally approximately one meter, but all the elements remained upright and stable. The test vehicle was smoothly redirected and the test was judged to be successful. Provided that this amount of

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Type 60K

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deflection can be accommodated, a freestanding downstream Type 60K barrier terminus is an acceptable configuration.

Future Research to Focus on Bridge Rails

Several roadside safety research projects are currently being planned. The first major project will be testing the Type 26 bridge rail. The Type 26 rail consists of a vertical concrete parapet, 685-mm high, and is generally mounted on a sidewalk. The Department has used this rail for many years, most often in low-speed urban areas where pedestrians are present. The Type 26 rail has never been formally crash tested to verify conformance with NCHRP Report 350 criteria, so this situation will be rectified.

Another project will entail crash testing a variety of miscellaneous roadside items whose crash performance is unknown. Examples of such items include utility cabinets, warning signs of poles combined with dual flashing beacons and "snow" signs and signposts that are rotated 90 degrees during adverse weather conditions to display warning or regulatory messages.

The most ambitious project will involve the development of one or more new aesthetic bridge rail designs. To provide local agencies and the public with a wider range of bridge rail choices during the planning process, the RTSB will work in cooperation with an advisory committee to develop innovative rail design concepts, evaluate them, and develop design details. The concluding steps will be to construct test articles and conduct crash tests. The advisory committee includes landscape architects, bridge architects, structural engineers and planners from HQ and the districts.

The Department may also have a private sector partner to assist in this endeavor. The FHWA strongly supports the use of finite element analysis in conjunction with crash testing to develop roadside safety hardware. Finite element analysis is a technique that may be used to simulate crash testing on a computer with the aid of sophisticated software. This simulation capability can be a powerful aid in developing new designs. To encourage the use of finite element analysis, FHWA provides funding to "Centers of Excellence" that enter into partnership with state departments of transportation to develop new safety hardware.

The Department, in cooperation with Applied Research Associates, Inc. (ARA), has proposed such a partnership. ARA is a Silicon Valley firm with extensive experience in finite element analysis work and they have applied to FHWA for designation as a Center of Excellence. If ARA receives the federal funding, they will assist the Department by evaluating the crashworthiness of proposed bridge rails through simulation modeling. In this way, designs can be modified to improve crash performance and increase the likelihood that the rails will pass the full-scale crash tests successfully.